DUNE Near Detector Discussion Meeting
February 27-29, 2020, Tata Institute of Fundamental Research, Mumbai, India

Active element: Technology choices

Jyoti Tripathi
On Behalf of PU Group

Department of Physics,
Panjab University, Chandigarh

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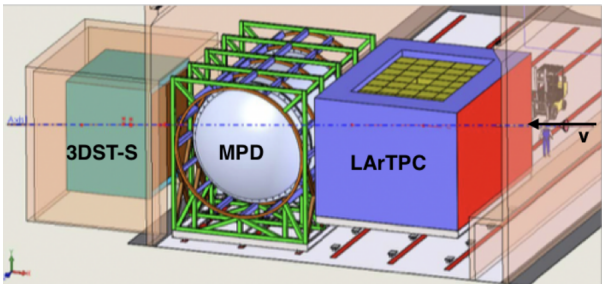
OutLine

- Baseline Design for DUNE ND
- Muon System for DUNE ND
- Technologies Available
- GEM Assembly
- Indian Participation in GEM Assembly
- Simulation
- Proposal from PU Group

DUNE Near Detector Design :

- Liquid argon time projection chamber (LArTPC),
- Followed by a multi-purpose detector (MPD),
- And a three-dimensional scintillating tracker-spectrometer (3DST-S)



Reference design for the DUNE near detector complex (Figure from DUNE Collaboration)

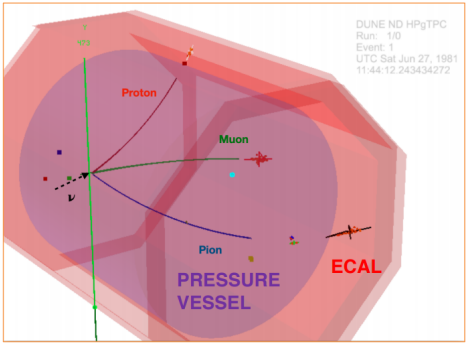
MPD Design

Design consists of :

- High Pressure Gaseous Argon TPC (HPgTPC)
- Surrounded by an Electromagnetic Calorimeter (ECal)
- HPgTPC and the ECal reside in a 0.5 T magnetic field

ECAL should be able to separate interacting pions from muons.

Muon tagger can help achieve better separation .

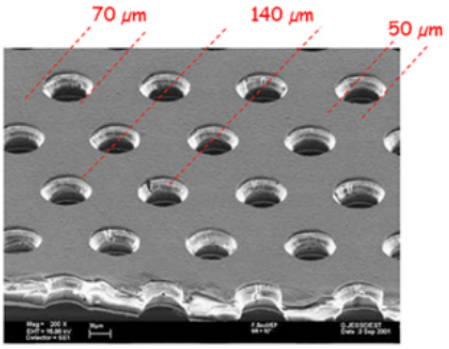


Jennifer Raaf TPC Mini Workshop July 11-12, 2019

Muon Detection technologies in use :

- Drift Tubes
- Cathode Strip Chamber
- Resistive Plate Chambers (RPCs)
- Straw Tubes
- GEM (Gas Electron Multiplier)

GEM - thin polymer foil with metal coating on both sides and pierced with a high density of holes.



- Large area devices with a compact size.
- Ability to operate well at high flux rate ($1.5 \times 10^6 \nu_\mu$ CC events per year in the HPgTPC).
- Can withstand high radiation.

GEM detectors have been used in several HEP detectors including :

- COMPASS (CERN): First high luminosity experiment to use the GEM technology. Twenty two 30 $\times$ 30 cm^2 triple GEM detectors installed in the inner tracking stations.
- TOTEM (CERN): Chambers operate in the $Ar/C0_2$ (70 : 30) at a typical gain of 8×10^3.
- LHCb (CERN): Gas mixture $Ar/CO_2/CF_4$ (45 : 15 : 40). Chambers operate at a gas gain of 4 to 6 $\times$ 10^3
- PHENIX (RHIC): GEMs operate in pure CF_4 at a gas gain of few 10^3

Indian Partcipation

Several Indian Institutions are involved in the GEM assembly for Compact Muon Solenoid (CMS) detector at CERN.

"GE1/1" - GEM detector installed in CMS to enhance muon trigger and reconstruction capabilities.

"GE1/1" - the "G" stands for GEM and the "E" for Endcap; the first "1" corresponds to the first muon station and the second "1" to the first, innermost ring of the station

Assembly sites for GE1/1 in India include -

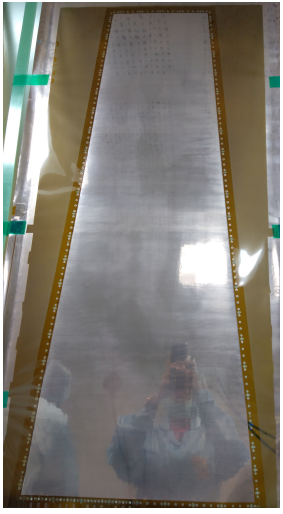
- Panjab University, Chandigarh
- Delhi University
- Bhabha Atomic Research Centre (BARC, Mumbai)
- Saha Institue of Nuclear Physics (SINP, Kolkata)

Clean Room for GEM Assembly

- A class 100 clean room at PU Site for the GEM Assembly.
- GE1/1 for CMS experiment at CERN has been assembled here.

GE1/1 Dimensions and Specifications

- 50 μm thick foil with 5 μm of copper coating on both sides (total 60 μm).
- Smaller Base = 279.0 mm
- Large Base = 510.0 mm
- GEM Height = 1283.0 mm
- Three GEM foils sandwiched in between drift and readout boards with a gap configuration of 3/1/2/1 mm.
- Total thicknes of GEM chamber = 7 mm (gap) + 3.2mm (Readout Board thickness) + (3.2 mm) Drift Board thickness = 14mm
- High Spatial Resolution $\sim$ 250 μm
- Time resolution $\sim$ 10 ns
- Angular resolution of 250 μm



Quality Control Tests

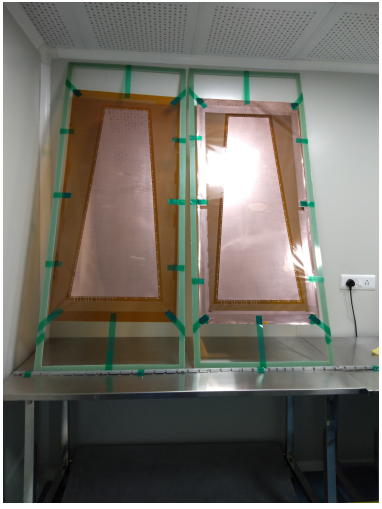
- Besides the assembly, several quality control tests performed including

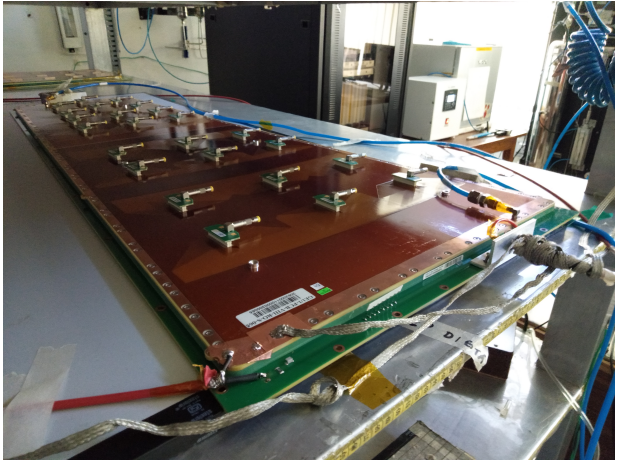
  - QC2 fast test - to determine the quality of GEM foils by measuring the maximum leakage current flowing on the surface of GEM holes.

  - QC3 leak test - to calculate GEM detector's gas leak rate by monitoring pressure drop as a function of time.

  - QC4 test - to study VI (applied voltage vs current) characteristics. Aims to identify possible malfunctions and defects in HV circuit and spurious signals.

GEM Assembly



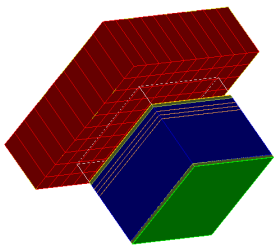


GEM Assembly

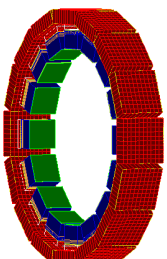
Studies done by PhD student Sunil Kumar working on GEMs.

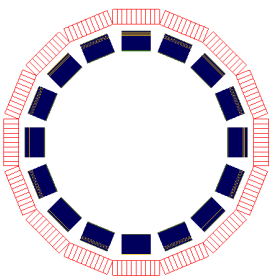
GEM Simulations using GEANT4

- Total 16 units of detector arranged in a ring.
- Each unit consisting of a GEM and a scintillation block.
- GEM Dimension = 10 cm $\times$ 10 cm $\times$ 8.9 cm



GEM detector simulations using GEANT4





PU Proposal

- Can take up GEM simulation work
- Need funds for a dedicated man power at PU.
- If needed, prototyping can also be done at PU.

  Need to understand the timeline for this as the group is currently engaged with the GEM assembly for CMS.

  Simulation studies can be performed as soon as PhD student joins the group.

- People interested for this at PU - Vipin Bhatnagar, Sushil Chauhan* and Jyoti Tripathi (*: faculty at PU, would join DUNE ND efforts for GEM activity - not a member yet)
- More PU-DUNE members can also join the efforts in future.

BACK UP SLIDES

PU Proposal

- One PhD student (monthly fellowship 35K)
- One work station for about 2 lakhs
- 50K per year for domestic travel (and 2.5 Lakhs per year for International short visits for presenting results or attending meetings).
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